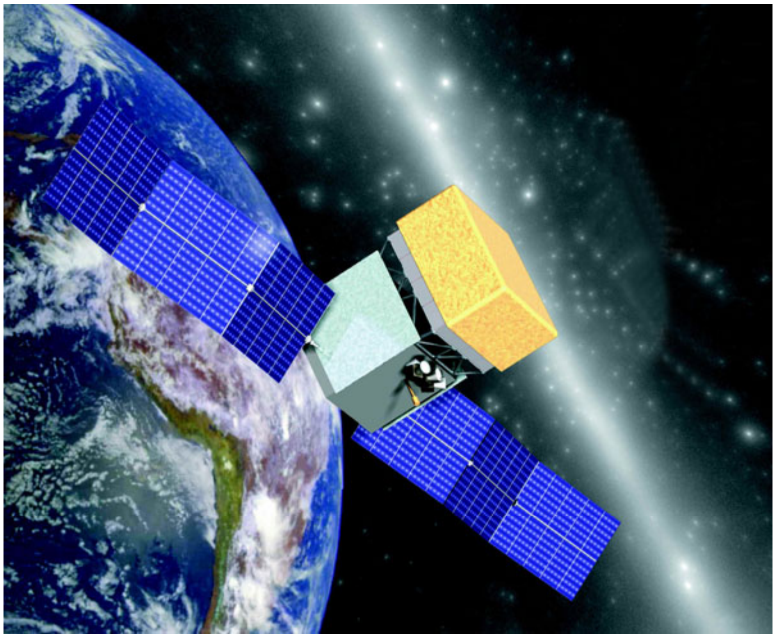
Gamma Ray Large Area Space Telescope



The Naval Research Laboratory (NRL) is a member of an international consortium that was recently selected by NASA to develop the primary instrument GLAST, the next major space mission to study high-energy astrophysics, is planned for launch in 2006 for a minimum five-year mission.

GLAST is the successor to the Energetic Gamma-Ray Experiment Telescope (EGRET) experiment on NASA's Compton Gamma Ray Observatory (CGRO), which recently ended its mission after many years of successful observations. GLAST will be 50 times more sensitive than EGRET and will detect gamma rays at high energies ranging from 20 million to 300 billion electron volts. The study of gamma rays is expected to provide essential insight into physical processes driving celestial objects.

Gamma rays are the most penetrating type of electromagnetic radiation, and allow a direct view of the high-energy processes acting in the innermost regions of cosmic accelerators such as pulsars, black holes, and supernova remnants. GLAST will precisely locate hundreds of mysterious gamma-ray bursts, recently shown to be the most powerful and distant explosions in the Universe since the Big Bang. It will be sensitive enough to detect several dozen gamma-ray pulsars, which, scientists say, will reveal new details about the life cycle of massive stars in our Galaxy.

NRL's Gamma and Cosmic Ray Astrophysics Branch is responsible for the design, development and test of the massive calorimeter for GLAST. The principal function of the calorimeter is to measure the energy of incoming gamma rays.

The main GLAST instrument is a wide field-of-view imaging telescope, which consists of a tracker that determines the trajectory of the gamma ray being measured, and the NRL-developed cesium-iodide calorimeter. A charged-particle anti-coincidence shield helps filter out unwanted signals, such as those produced by background particles.

Once a gamma ray penetrates the shield, it interacts in the tracker and is converted into electron-positron pairs (matter and antimatter) that multiply and cascade into a "shower" of charged particles and photons (also known as an electromagnetic shower). The calorimeter collects and measures the energy from these showers to determine how much energy is in each gamma ray.

The passage of these particles through the cesium-iodide crystals produce flashes of scintillation light that are photoelectrically converted to voltages, or electrical signals. These signals are then digitized, recorded and relayed to Earth by the spacecraft's onboard computer and telemetry system. Cesium-iodide blocks are arranged in two perpendicular directions, to provide additional positional information about the shower.

The accuracy of the energy measurement is largely determined by the calorimeter's ability to collect all the energy from the shower of particles created by the interaction of the gamma ray with the GLAST instrument. The penetrating nature of these particles requires a massive calorimeter to stop or capture them. In GLAST, the calorimeter is about 60% of the weight of the experiment. GLAST uses 1350 kg of thallium-doped cesium iodide, CsI(Tl), scintillation crystals to form the calorimeter. These crystals, known for their durability and high resistance to thermal and mechanical shock, look much like rock salt, but are polished like lead glass and emit light when gamma rays or charged particles interact with them. GLAST uses over 1500 CsI crystals.

NRL's High Energy Space Environments Branch is responsible for building the computers used to discriminate gamma rays from background cosmic rays in the events seen by GLAST. The problem is challenging because background events are several thousand times more numerous than the gamma rays. The gamma rays must be distinguished from the cosmic rays by differences in patterns produced by energy deposited in the tracker and calorimeter. Crucial first stages of this pattern recognition are done in the onboard computers. The high data volumes and event rates call for a high throughput computing system, able to operate reliably in the space radiation environment. NRL has built a prototype processor, using the PowerPC 603e chip flying in DoD's first flight testbed for space-based computing systems on the ARGOS satellite, results from which are being applied to the GLAST design.

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